RADIO FREQUENCY REMOTE GAME CONTROLLER

BACKGROUND OF THE INVENTION

The invention described herein relates to the field of remote game

5   controllers for operating electronic games.   More particularly, the invention

relates to a radio frequency operated remote game controller for operating an

electronic game device.

Electronic games use software and hardware devices to simulate game

situations and experiences through visual and audio stimulus. Such games

10   provide interactivity with a person through a controller which permits the person

to change the game direction or response. Many games are fast moving and

draw the user into fast moving responses which integrate the person into the

game. Popular games require fast reflexive responses to the game situation and

format, and require the transmission of large data sets. Any interruption of such

15   game is disruptive to the person's enjoyment and is highly undesirable.

Conventional game controllers are typically hard wired to the hardware or

alternatively transmit data signals with infrared frequency transmission. Hard-

wired controllers are capable of reliable, fast signal communication, however

such controllers require wires leading from the controller to the hardware. Such

20   wires present a safety hazard because persons and pets can trip over the wires,

and further limit the operating mobility of the user relative to a central controller.

Infrared frequency ("IR") controllers are conventionally used in many

remote control devices including controllers for televisions, stereos, and other

1

remote controlled devices. IR controllers are undesirable because a moving person or pet can interrupt the communication link with the hardware at the most undesirable time during the game play, and because the IR controller must be pointed substantially at the hardware to maintain the communication link.

5   Additionally, the number of channels open to IR controllers within a room is limited because the IR controller light sources illuminate the room with scattered light, thereby reducing the capability of the room to transmit any additional concurrent IR communications. Although IR light can be modulated, the number of effective communication lines operable within a single room is limited.

10   Certain multiple game devices have been proposed to permit simultaneous, multiple user operation of a game system, however such systems typically hardwire the controllers to the central control system and to other controllers. For example, United States Patent No. 5,538,255 to Barker (1992) disclosed a system for a remote controlled multiplayer video game. United

15   States Patent No. 5,292,125 to Hochstein et al. (1991) disclosed a video game communicator electrically connected with telephone lines, and United States Patent No. 4,372,558 to Shimamoto et al. (1979) also disclosed a remote game apparatus using a telephone line as the communication means.

United States Patent No. 4,531,740 to Green et al. (1985) disclosed a

20   remote controller system for a video computer game which used radio frequency ("RF") transmission as a communication mechanism and required a reset mechanism on a control center. Data was transmitted through different

channels, significantly limiting the flexibility of a controller and limiting the number of users able to simultaneously operate the game system.

Another radio broadcast system was disclosed in United States Patent No. 5,806,849 to Rutkowski (1998) wherein long range signal transmission was

5   proposed. Such system also depended on multiple channel transmission and used a single receiver to poll individual channels. Such polling requirement significantly increases delay in signal processing and limits high data transmission required in remote game transmission.

Conventional game controller systems often provide multi-user

10   capabilities and power efficiency based on frequency domain multiplexing ("FDM"). FDM uses multiple frequencies or channels to carry multiple signals through a common airspace, or one signal per channel. Systems incorporating FDM are undesirable because of additional cost and complexity, and because a larger transmission spectrum is required for the communication footprint. This

15   requirement increases the possibility of signal interference from other signals, and with the possibility of controller interference with other products and appliances.

Accordingly, a need exists for an improved game controller system which does not have the limitations of prior art controllers. The system should

20   efficiently and accurately transmit large quantities of data and should provide flexibility to permit operation by multiple users.

SUMMARY OF THE INVENTION

The invention provides a system for communicating between a person and an electronic game device. The game controller comprises a housing, a sensor attached to the housing and responsive to operation by the person to

5 generate signals, a radio frequency sender engaged with the sensor which is capable of time domain multiplexed transmission of the signals, and a radio frequency receiver engaged with the electronic game device for receiving the signals from the radio frequency sender.

In other embodiments, the invention provides a game controller system

10 for communicating between at least two persons and an electronic game device which comprises a housing, a sensor engaged with the housing and responsive to operation by the persons to generate signals, a radio frequency sender engaged with the sensor for time domain multiplexed transmission of the signals, and a radio frequency receiver engaged with the electronic game device for

15 receiving the signals from the radio frequency sender.

The method of the invention is practiced by operating a sensor engaged with a housing to generate signals in response to operation by the person, by detecting the signals with a radio frequency sender engaged with the sensor; by operating the radio frequency sender to transmit the signals with time domain

20 multiplexing, and receiving the radio frequency sender signals with a radio frequency receiver engaged with the electronic game device.

4
5

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a controller having a transmitter for sending signals to a RF receiver.

Figure 1a illustrates multiple controllers engaged with a single receiver.

Figure 2 illustrates multiple controllers engaged with multiple receivers.

Figure 2a illustrates multiple controllers engaged with a single game system having multiple receiver functions.

Figure 3 illustrates a one second (1000mS) in which are transmitted eleven 1mS data packets (not to scale).

Figure 4 represents a collision between two transmitters operating on the same channel.

Figure 5 compares RF with IR signal transmission.

Figure 6 illustrates a combination of time domain multiplexing in one direction with IR or another signal transmission in an opposing direction.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention provides a system for remote communication between a user and an electronic game device. The invention uniquely provides uninterrupted RF data communication between multiple users and time domain multiplexed ("TDM") transmission within one or more channels to save battery power and to enhance data transmission with a reduced spectral footprint and diminished radiated energy. The invention provides unique capabilities to transmit data at fast rates, provides for "burst" transmissions, and provides for

addressed communications between one or more transmitters and one or more receivers.

As shown in Figure 1, controller 10 has sensors or keys 12 which perform different operating functions. Keys 12 can be responsive to pressure, audible

5 sounds, light, movement, and other stimulus. Figure 1 illustrates an RF sender such as transmitter 14 which is attached to controller 10 and broadcasts signals to RF receiver 16 integrated with electronic game device 17. RF receiver 16 can be hard-wired into electronic game device 17 or can comprise a remotely connected or plug-in module attachable to electronic game device 17.

10 Transmitter 14 can be mated with receiver 16 by indexed names, signals, or selected addresses by assigning unique address codes to each controller. As shown in Figure 1a, multiple controllers 10 can be engaged with a single receiver 16 and game device 17.

As shown in Figure 2, multiple controllers 10 with corresponding

15 transmitters 14 can be integrated with multiple receivers 16 to create game system 18. Alternatively, one or more receivers 16 can operate with one or more controllers 10 in different combinations of the invention. For example, as illustrated in Figure 2a, two controllers 10 can be engaged with a single game device 17 having two receiver functions 16.

20 As used herein, the term "TDM" refers to the use of different intervals of time to carry multiple signals on the same RF frequency or channel or other medium. Because each signal requires only a small percentage of time within a discrete time interval, the invention permits many signals to share the same

channel. TDM is possible over an RF channel, a single wire, or an optical link.
Accordingly, the use of TDM for game applications is extendible to transmissions
other than exclusive RF transmissions.

The invention is particularly suited to game applications because of the
5   random timing and low frequency of controller events required for game
applications. Controller events are defined as a change in state of the set
defined by controller keys 12. For example, if controller 10 has sixteen keys, an
event occurs when the state of any key 12 changes. To ensure synchronization
between transmitter 14 and receiver 16, the entire state of keys 12 is transmitted
10   each time an event occurs. The following example represents operation of one
key 16 in three states and two events:

State:	Event Transmitted:
0000 0000 0000 0000	
0000 1000 0000 0000	0000 1000 0000 0000
0000 0000 0000 0000	0000 0000 0000 0000

The following example represents operation of two keys 16 being pressed and
released:

State:	Event Transmitted:
0000 0000 0000 0000	
0000 0000 0100 0000	0000 0000 0100 0000
1000 0000 0100 0000	1000 0000 0100 0000
1000 0000 0000 0000	1000 0000 0000 0000
0000 0000 0000 0000	0000 0000 0000 0000

A packet of data, representing the state of all keys 12, is transmitted from
transmitter 14 to receiver 16 each time an event occurs. In another embodiment

7 8

of the invention, the packet size of transmitted data can be reduced by transmitting only the changes in the data transmission.

Figure 3 represents a single second of time in which eleven 1mS packets are transmitted (not to scale). This can be accomplished with a 56 kbps (56,000 bits per second) transmission rate because in 1mS 56 bits can be transmitted to provide for sixteen bits of state information in addition to address and other overhead information.

For game operations, the number of events and required number of packets should not ordinarily exceed thirty per second. Assuming 1mS packets, 30/1000 of the second is used and 970/1000 of the second is available for transmission of additional data on the same channel.

By using TDM in the transmission of data and signals, controls should be implemented to control and manage "collisions". A collision occurs when data from one signal collides with or interrupts data from another signal on the common medium. Although many different techniques can be used to avoid or to control collisions, one embodiment of the invention uses random delay resend to transmit a copy of each packet after a random delay. Figure 4 represents such transmission wherein two transmitters 14 are located on the same RF channel. As illustrated, a data collision occurs on the first packets A1 and B1 because both transmitters 14 attempt to transmit at the same time. Receiver 16 can detect collisions through error detection techniques such as checksums, parity, CRC, or other techniques. Collision detection by receiver 16 causes receiver 16 to ignore the damaged data, and the copies of the respective data

8

packets are retransmitted after a random delay. In Figure 4, A1c is retransmitted 2mS after the end of A1, and B1c is retransmitted 5mS after the end of B1. If the original packets (A1 and B1) have not collided, receiver 16 will ignore the retransmitted copies because such copies can be marked accordingly.

5   Synchronous communication involves slices of time which are clearly identified and assigned to respective data streams. Because of this clean allocation of time slots to data streams, collisions are virtually eliminated. This type of communication is not desirable for RF gaming because a data link would be required between controllers in order to synchronize the timing of

10   transmissions. This requirement would significantly complicate the system. Accordingly, preferred implementations of TDM involve collision management techniques using redundant, random-delayed resends, or listen-before-send techniques.

A listening function can be used to "listen-before-send" without requiring

15   duplex or bi-directional communication. This feature of the invention simplifies data transmission by permitting transmission in one direction instead of in two directions. A transmitter 14 that wishes to transmit can first monitor the channel to determine whether traffic exists. After the channel is confirmed as clear, transmitter 14 can transmit as a simplex or one direction communication. Other

20   techniques can be derived to provide for signal transmission in one direction between transmitter 14 and receiver 16, or vice versa. If confirmation of signal transmission was desired, bi-directional transmission could be included in an alternative embodiment of the invention.

/O

In another embodiment of the invention, time domain multiplexing can be combined with frequency domain multiplexing so that multiple channels are used in combination with multiple users operating on each channel. This combination would permit two or more transmitters 14 to transmit data on each channel while

5   permitting expansion of the signal transmission capabilities over multiple channels.

The invention can use "burst" transmission wherein transmitter 14 does not continuously transmit data packets, but transmits data in a plurality of relatively short, discrete time interval "bursts". Transmitter 14 is disabled

10   whenever a packet is not being transmitted and is only enhanced during very brief periods ("bursts") during which a packet is transmitted. The RF carrier is therefore suppressed at all times except during such bursts. This feature of the invention reduces the actual operation time of transmitter 14, and reduces the energy required by controller 10. Accordingly, battery life is extended and active

15   gaming play time interruption is reduced. Moreover, the amount of energy radiated by controller 10 is reduced, therefore reducing interference.

In one application of the invention, one or more controllers 10 can transmit multiple data sets on a single channel. In another application, one or more controllers 10 are capable of transmitting on different channels

20   simultaneously. Additionally, controller 10 is capable of changing from one channel to another, thereby providing flexibility in game operation between multiple users. A user can press a "channel key" on controller 10, and controller 10 then broadcasts a command on all channels telling the mated receiver 16 to

change to channel "A". Controller 10 then switches to channel "A". The mated

receiver 16 has already received the command and also switches to channel "A".

Because the broadcast signal was sent on all channels, the prior operating

channel of receiver 16 does not inhibit the ability of controller 10 to connect with

5   receiver 16. All other non-mated receivers 16 also receive the same broadcast

signal, however the other receivers 16 ignore such broadcast signal because

such receivers are mated with other controllers 10.

Although different RF frequencies are possible, frequencies exceeding

300 MHz are preferred. This frequency range provides another advantage of

10   eliminating the need for an external antenna with controller 10 or with receiver

16. The absence of required antennas is significant for providing easy and

damage free operation of game systems. Operation of the invention at high

frequency enables high data rates (56,000 bps and higher) which in turn enables

very short burst transmissions. These short burst transmissions enable time

15   domain multiplexing, enhance power efficiencies, and reduce the radiated RF

energy. This combination also reduces the possibility of potential interference.

The invention operates at high data transmission rates which reduces

delay in signal transmission and enhances game play response. Rates of

56,000 bps permit the transmission of 56 bits in 1mS. A 1mS transmission, for

20   example, can accommodate a 56 bit packet comprised of a 16 bit event plut 40

bits of address, framing and error detection/correction information. For infrared

transmission typically used in conventional game systems, the same event

having one-half the bits may require 3mS, thereby establishing RF transmission

11

in the invention as a significantly faster (by three hundred percent) mechanism

for transmitting data in game operations. Burst transmission of such 1mS

packets each containing, for example, 56 bits, allows for sufficient overheads

such as addresses, packet framing and error detection/correction. Because the

5   incidence of packets created by any one transmitter would be 60 or fewer per

second including duplicates, TDM is possible because one transmitter 14 uses

only 60/1000 or six percent of the channel, and ninety-four percent of the

channel is available for other traffic.

Data packets are encapsulated so that layers of bit framing, error

10   detection, address, and key 12 state information are encapsulated within the

same packet. Error control and recovery can be accomplished with universal

asynchronous receiver/transmitter (UART) oriented protocol. Alternatively,

forward error correction can be implemented to eliminate the need for other error

correction techniques. Guard patterns can be integrated for error detection, with

15   guard bits in selected patterns surrounding data packets. If receiver 16

observed a defect in such guard patterns, receiver 16 would be alerted that the

integrity of the packet had been breached.

An LED lamp such as display 22 can provide visual information regarding

data received or transmitted by RF transmitter 14. Although the use of

20   addresses permits time domain transmission between the correct transmitter 14

and receiver 16, controller 10 can be temporarily reprogrammed with the

address code of a foreign receiver, enabling it to function with the foreign

receiver for a period of time if required.

12 /3

IR transmissions are typically realized utilizing data rates much lower than 56,000 bps. The IR technology consequently has a diminished ability to create very short burst transmissions which in turn limits the TDM possibilities. Conventional IR controller solutions are limited to two controllers, whereas the

5   invention can be incorporate one or more splitters or multitaps attached to receiver 16 to add additional controllers 10 to communicate with the same receiver 16. The higher data throughput provided by using RF provides suitable operation for advanced or next generation game controllers such as those utilizing analog joystick control.

10   A natural delay is built into data transmission regimes. Figure 5 illustrates the respective data transmission signals for IR and RF data signals. For example, for a hard-wire controller, the T1 delay can comprise a statistically number in the range $0 < T_1 < 6.6$ milliseconds.

In another embodiment of the invention, each controller can transmit data

15   over separate channels within the RF spectrum. The flexibility to operate controllers over different channels, and to multiplex data transmission from different controllers over the same frequency, permits flexibility in the system capability to operate multiple controllers in the same room with one or more radio frequency receivers and electronic game devices. If TDM permits three

20   controllers 10 on the same channel, a twelve controller system uses four frequencies or channels instead of twelve.

In addition to the speed capabilities of RF transmission techniques taught by the invention, a low duty cycle (six percent in the earlier example) of

13 /4/

transmitter 14 permits transmitter 14 to be turned off most of the time (ninety-four percent in this example). The energy saving feature of the invention is particularly important for portable game controllers subjected to long, continuous play periods. By conserving battery power, the system design of the invention

5   provide for longer operating times for the same battery power, which minimizes game disruption.

Whereas time domain multiplexing is conventionally used in continuous data transmission utilizations, the invention uniquely uses time domain multiplexing to transmit real time data for the purpose of game control

10   transmission. Event driven transmission provides enhanced responsiveness over polling and other techniques because data transmission occurs immediately after the occurrence of an event. The absence of a designated transmission time is energy efficient and provides greater flexibility in the transmission of more data packets. This feature reduces transmission delays and provides

15   enhanced controller 10 responsiveness to the user. As used herein, the term "user" can comprise a person, another controller, or other mechanism.

Modulation of the RF signal can be accomplished with ASK, FSK, Quadrature modulation, spread spectrum, or other techniques. Events can be compressed to lower the event count and to assist time domain modulation. By

20   lowering the number of events, collisions will be reduced and more users can function on each channel.

In another embodiment of the invention, RF can be combined with IR transmission in different ways. For example, force feedback of controller 10 can

14 15

be implemented by shaking or vibrating controller 10 to provide operating

feedback to the user. A reverse IR data path could be implemented to enable

such a force feedback feature. A simple IR path could be implemented next to

the RF path in the same or opposite direction to provide alternative data

5   transmission capabilities as illustrated in Figure 6.

In another embodiment of the invention, listen-before-send capabilities

can be added to controller 10. For example, a carrier detect on controller 10

could provide the capability of determining whether another controller is

transmitting or not at a certain time. Having controller 10 listen for traffic prior to

10   sending would reduce collisions dramatically. This would reduce the system

dependence on redundant packet transmissions and would create increased

TDM efficiencies by permitting more users per channel.

Gaming systems are preferably economic to manufacture, which requires

the fewest number of components. Battery operation and long hours of

15   continuous use dictate power efficiencies in remote components. Although

different combinations are possible as described, single-channel is preferable to

multi-channel communication even though TDM can be implemented to enhance

both multi and single-channel systems. Burst transmission is preferable to

continuous transmission, because TDM effectively uses brief signal

20   transmissions. The simplicity of single-direction (simplex) is preferable to two-

direction (duplex) even though duplex systems can be designed to work with

TDM gaming systems disclosed herein. Asynchronous communication is

preferable to synchronous communication because data links between multiple

controllers would not be required to synchronize the timing of multiple

transmissions.

Although the invention has been described in terms of certain preferred

embodiments, it will be apparent to those of ordinary skill in the art that

5   modifications and improvements can be made to the inventive concepts herein

without departing from the scope of the invention. The embodiments shown

herein are merely illustrative of the inventive concepts and should not be

interpreted as limiting the scope of the invention.